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A TE-TM Mode Splitter Using Annealed Proton Exchange and Zinc/Nickel Co-diffusion Waveguides

Jiun-Yun Li, Wen-Hao Hsu, and Way-Seen Wang, *Member, IEEE*

Department of Electrical Engineering and Graduate Institute of Electro-Optical Engineering

National Taiwan University, Taipei 10617, Taiwan, ROC

Fax: +886-2-2362-1950, Email: wswang@cc.ee.ntu.edu.tw

Abstract - A novel zinc/nickel co-diffusion and conventional annealed proton exchange (APE) process is used to fabricate a heterogeneous Y-junction TE-TM mode splitter on z-cut $LiNbO_3$. High extinction ratios, 22dB for TE and 25dB for TM modes, are obtained.

I. INTRODUCTION

TE-TM mode splitter, an important device in coherent optical detection, can be fabricated using Y-junction or directional coupler. A Y-junction type TE-TM mode splitter is based on the mode sorting effect [1]: TE and TM components of the input randomly-polarized wave can be split according to the polarization preference of the output branches. It is more tolerable to fabrication error and insensitive to wavelength variation, compared to the direction coupler type one [2].

Recently, $Zn:LiNbO_3$ waveguide has retrieved much attention due to its potential to make more photo-refraction-resistant and lithium out-diffusion-free optical devices [3]. Both Ni and $Zn:LiNbO_3$ waveguides have the process-dependent guiding property, which means the guided polarization can be changed by using different fabrication parameters, such as film thickness and diffusion condition [4]. We have found that by adding Ni, the capability of guiding ordinary wave in $Zn:LiNbO_3$ waveguide is increased and good to fabricate waveguides that support ordinary waves only.

In this work, zinc/nickel co-diffusion is used to fabricate the TE branch of the TE-TM mode splitter to demonstrate the increased capability of guiding ordinary wave in $Zn:LiNbO_3$ waveguides. Extinction ratios greater than 20dB are obtained.

II. EXPERIMENTS

The proposed TE-TM mode splitter on a z-cut $LiNbO_3$ substrate is illustrated in Fig. 1. There are mainly three parts: 1) Input, which supports both TE and TM modes, 2) TE branch, which follows the input part straightly and supports only TE-polarized wave, and 3) TM branch, which is bent from the input waveguide at an angle of 0.5° and supports only TM-polarized wave. The width of all waveguides is 6μm, which is good for single mode propagation at an operating wavelength of 1.3 μm.

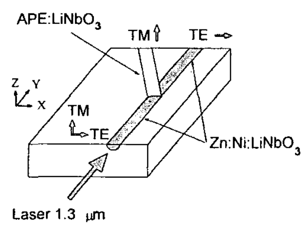

Fig. 1 Y-junction TE-TM mode splitter

The fabrication process and parameters for these three parts are listed in Table 1. For the input and TE-branch, waveguides are formed by Zn/Ni co-diffusion, in which process a Ni and a Zn layers are deposited onto the substrate in order and then oxidized and diffused in furnace. The oxidation is necessary for Zn to become

ZnO, which is the source really diffused in. In the fabrication of our device, the oxidation process is done at 400 °C for 2~4 hr.

Table 1 Fabrication process and parameters.

Segment	Waveguide Fabrication	Temp. (°C)	Time (hr)	Anneal
Input	Zn/Ni: 1750/200Å Co-diffusion	950	3	No
TE-Branch	Zn/Ni: 750/200Å Co-diffusion	950	3	No
TM-Branch	APE Process	220	1	350 °C 1hr

Firstly, a 6μm-wide Zn/Ni strip of thickness 750/200Å is deposited onto the input and TE-branch parts. Another 750Å-thick Zn strip is then deposited onto the pre-formed Zn/Ni strip only in the input part. Therefore, the thickness of Zn/Ni strips in input and TE-branch are 1500/200Å and 750/200Å, respectively. The sample is then co-diffused at 950 °C for 3 hr. Secondly, the TM-branch is made by APE, which increases only n_e. Benzoic acid is used as the proton exchange source at 220 °C for 1 hr, and then a 1-hour post annealing is performed at 350 °C. It is found that the APE process has no influence on the guiding property of pre-formed Zn/Ni co-diffusion waveguides.

III. Results and Conclusion

The fabricated TE-TM mode splitter is then measured at a wavelength of 1.3μm Nd:YAG laser by end-fire coupling. The output mode profile is captured by a CCD camera. Fig. 2 shows the results of randomly-polarized input, TM-mode, TE-mode, respectively. High extinction ratios, 25dB for the TE mode and 22dB for the TM mode, are obtained. The losses of TE and TM modes are measured to be 1.2dB/cm and 1.0dB/cm, respectively. We conclude that the existence of Ni increases the capability of guiding ordinary wave in Zn:$LiNbO_3$ waveguide and therefore, TE-TM mode splitter with high extinction ratio can be successfully fabricated.

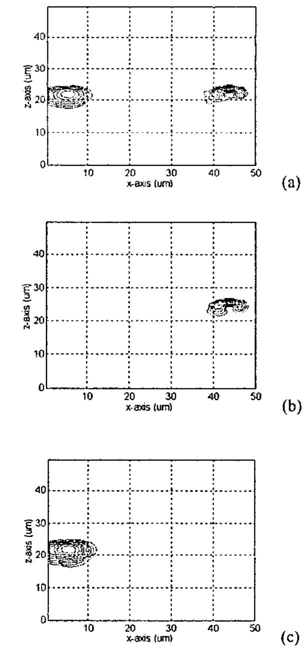

Fig. 2 Output near field distributions. (a) Randomly-polarized input, (b) TM mode, and (c) TE mode.

Acknowledgment

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References

[1] P. K. Wei and W. S. Wang, *IEEE Photo. Tech. Lett.*, Vol.6, No.2, p.245, 1994.

[2] H. Maruyam, M. Haruna, and H. Nishihara, *J. Lightwave Tech.*, Vol.13, No.7, p.1550, 1995.

[3] W. M. Young, M. M. Fejer, M. J. F. Digonnet, A. F. Marshall, and R. S. Feigelson, *J. Lightwave Tech.*, Vol.10, No.9, p.1238, 1992.

[4] Y. P. Liao, R. C. Lu, C. H. Yang, and W. S. Wang, *Electron. Lett.*, Vol.32, No.11, p.1003, 1996.